Epilogue

A Glimpse at the Future of Solar System Exploration

The road that leads to the future of any endeavor is usually well defined only at its start. Quickly, the future becomes obscured by latent uncertainties: the possibility of new discoveries, changing paradigms, changes in national policy, blind alleys, and funding pleasures and disappointments. Solar system exploration is no exception.

Throughout most of its study, the SSE Survey focused on understanding the current status of solar system exploration and, to the best of its ability, determining the optimum direction for solar system exploration into the future. This is embodied in the system of priorities presented in Part Two. But where this road will eventually lead in the more distant future is difficult to forsee for all of the above reasons. Nevertheless, the Survey does have significant expectations that are worth discussing briefly here and that may have value for long-term planning.

THE COMPLEXITY OF THE INITIAL VECTOR TOWARD THE FUTURE

Four decades of steady progress made possible by increasingly capable missions supported by programs of Earth-based observations, individual research, interpretational data analysis, and technological development are clearly paying off. Our understanding of the origins, evolution, and nature of planets and moons, and of asteroids and comets, is now much improved over the more superficial view of the late 1950s, as is our knowledge of many of the specific physical and chemical processes characteristic of these bodies. Rapid advances have brought us to the point that a major investment in sample-return missions, for example, Mars exploration, is now anticipated. Recent telescopic discoveries have opened up new frontiers for understanding processes in the primitive solar system, for example, in the outer solar system beyond Neptune, for which vigorous reconnaissance by robotic spacecraft is the most appropriate strategy. As a result, contemporary priorities reflect a complex mix of mission types, technological demands, and research objectives, all with high scientific merit but with widely differing technical readiness and expectations for completion. This complexity is at the root of the difficulties in predicting future outcomes of the exploration program.

ANTICIPATION OF NEW DISCOVERIES

All missions currently flying or being prepared for flight and allied ground-based research projects, both in the United States and internationally, will undoubtedly lead to new and unpredictable discoveries, which is the nature of exploratory projects. Discovery is the essence of exploration. Taken together, missions such as Rosetta, Stardust, and Deep Impact can be expected to have a revolutionary effect on our understanding of the role of comets in how giant planets are seeded and the origins of primitive organic materials and volatiles and their distribution throughout the solar system. In addition, research in closely related fields such as the search for and characterization of planetary systems around other stars or the study of protostellar disks and early stellar evolution, programs that are strongly supported by the astrophysics community, will also yield results at unpredictable times in the future that will demand changes in the paradigm for solar system formation and thereby could change how solar system exploration is pursued, particularly for the giant planets and Kuiper Belt objects. The mission priorities offered in this survey are a good example of such influences, for they very much reflect discoveries of the recent past. The Kuiper Belt-Pluto Explorer that the SSE Survey advocates so strongly today would have been an unlikely candidate a decade ago, before the ground-based discovery of large numbers of Kuiper Belt objects exhibiting a fascinating variety of physical properties; the Europa Geophysical Explorer would have been an unlikely focus for astrobiology before the detailed explorations of that moon by the Galileo mission just 7 years ago. This experience assures us that the prime scientific focus of solar system exploration a decade from now, although not necessarily predictable, will certainly be enormously exciting.

CHANGE

The future of solar system exploration will also be conditioned by changes in the infrastructure that guides it, the political system that nurtures it, and the public that supports it. All of these units have considerable inertia against change. However, some changes can be anticipated: for example, the organization and division of responsibility within NASA's Office of Space Science may change. In politics, potential for change in the level of available resources exists following every national election, and it must be remembered that the SSE Survey's list of five prioritized medium-class missions in Chapter 8 is based on the out-year funding levels proposed in the President's budget for 2003, funding levels that are not currently secure. Public support can change in response to dramatic events, as we have recently seen in the possible discovery of the fossilized remains of extraterrestrial life within a meteorite, or possibly, in the future, owing to the unexpected collision of some modestly sized object (100 m or more in size) with the Earth. All of these complexities can affect the future in unknowable ways. All that we can be sure of is that such changes will occur.

Given these uncertainties, is there anything that we can depend upon to help us understand the future of this endeavor? The broad surveys of the subject in Part One give part of the answer: The future program requires a mix between medium- to large-class missions that can adequately challenge current scientific paradigms. It also requires small missions, whether Discovery, Mars Scout, or mission extensions, that can provide focused ways of responding quickly to discoveries made or provide vehicles for entrepreneurial creativity and new scientific ideas. The SSE Survey's proposed Kuiper Belt-Pluto Explorer may be the last great reconnaissance mission within solar system exploration and, if Part One tells a story at all, it is that we are rapidly entering a phase of large- and medium-class missions operating on the surfaces of planets or within their atmospheres and plasma environments that will utilize technologies, yet to be practically developed, that will enable long sojourns, power advanced instrumentation, and return samples to Earth. These technical developments and in situ explorations are essential if we are to achieve acceptable answers to the basic challenges and motivational questions discussed in Part Two.

Solar system exploration is a grand human endeavor. It seeks to discover the nature and origins of the system of planets in which we live, to discover whether life exists beyond Earth, to prepare for human utilization of places in the solar system, and to understand the potential dangers of our space environment. Solar system exploration is also an international endeavor of global extent. That its future is secure seems obvious, even though the details are seen but through a mist. We are compelled to pursue it not only because it represents a physical and technological challenge but also because it places answers to profound questions within our grasp.